FIG. 1

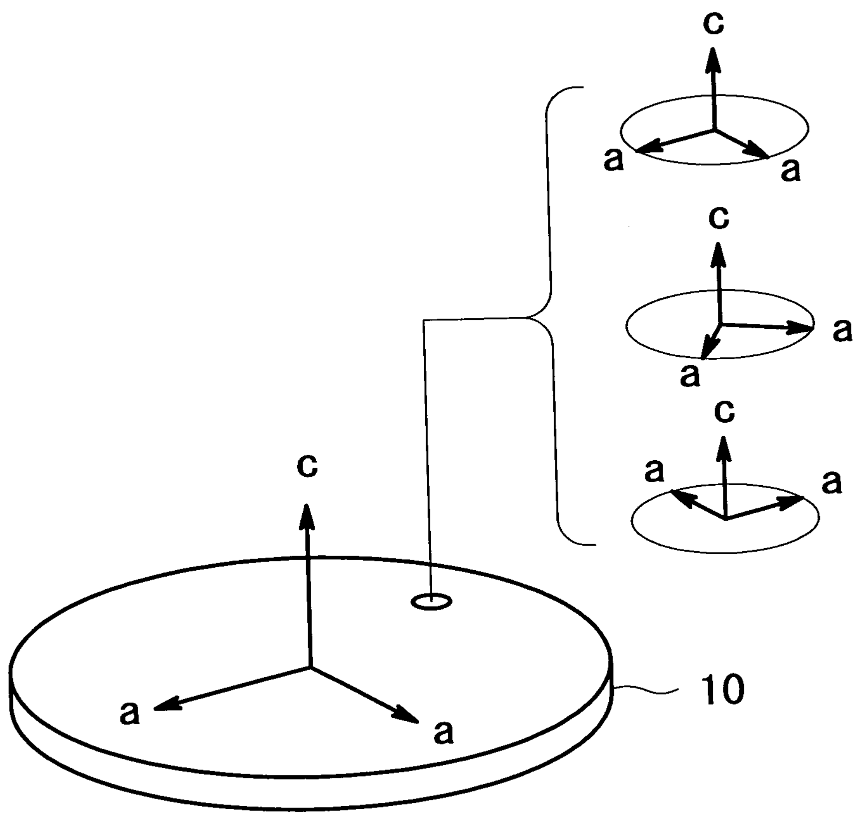


FIG. 2

$$\lambda = 2d \sin\theta \qquad \cdots(1)$$

λ : X-RAY WAVELENGTH

d: LATTICE SPACING

θ : BRAGG'S DIFFRACTION ANGLE

$$\frac{\partial d}{d} = -\cot\theta\ \partial\theta \qquad \cdots(2)$$

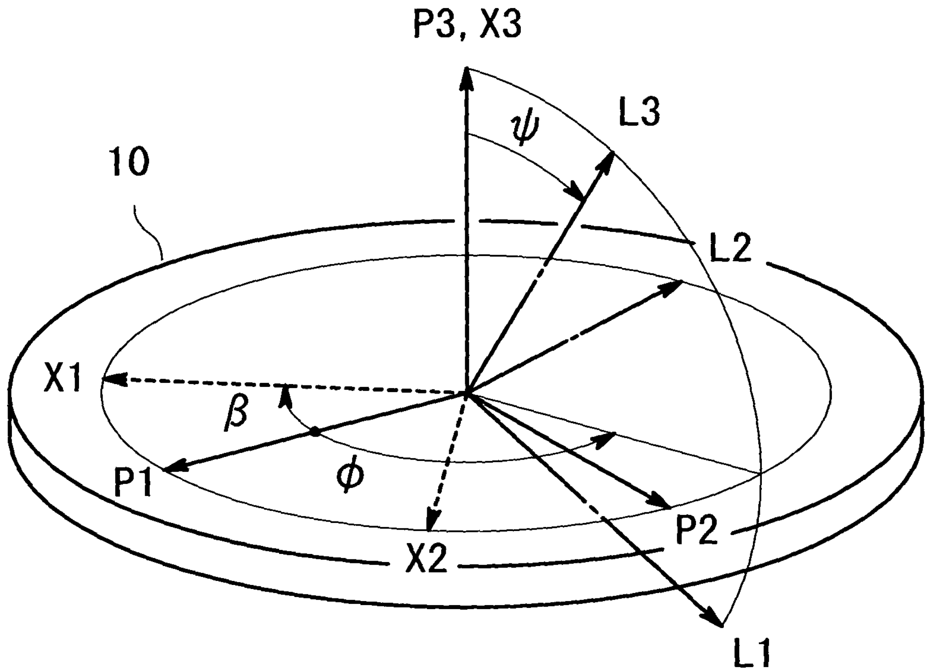
$$\varepsilon = \frac{d - d_0}{d_0} \qquad \cdots(3)$$

ε : STRAIN

d_0 : LATTICE SPACING IN NON-STRAIN STATE

$$\varepsilon = -\cot\theta_0(\theta - \theta_0) \qquad \cdots(4)$$

FIG. 3



P: SPECIMEN COORDINATE SYSTEM

X: CRYSTAL COORDINATE SYSTEM

L: LABORATORY COORDINATE SYSTEM

FIG. 4

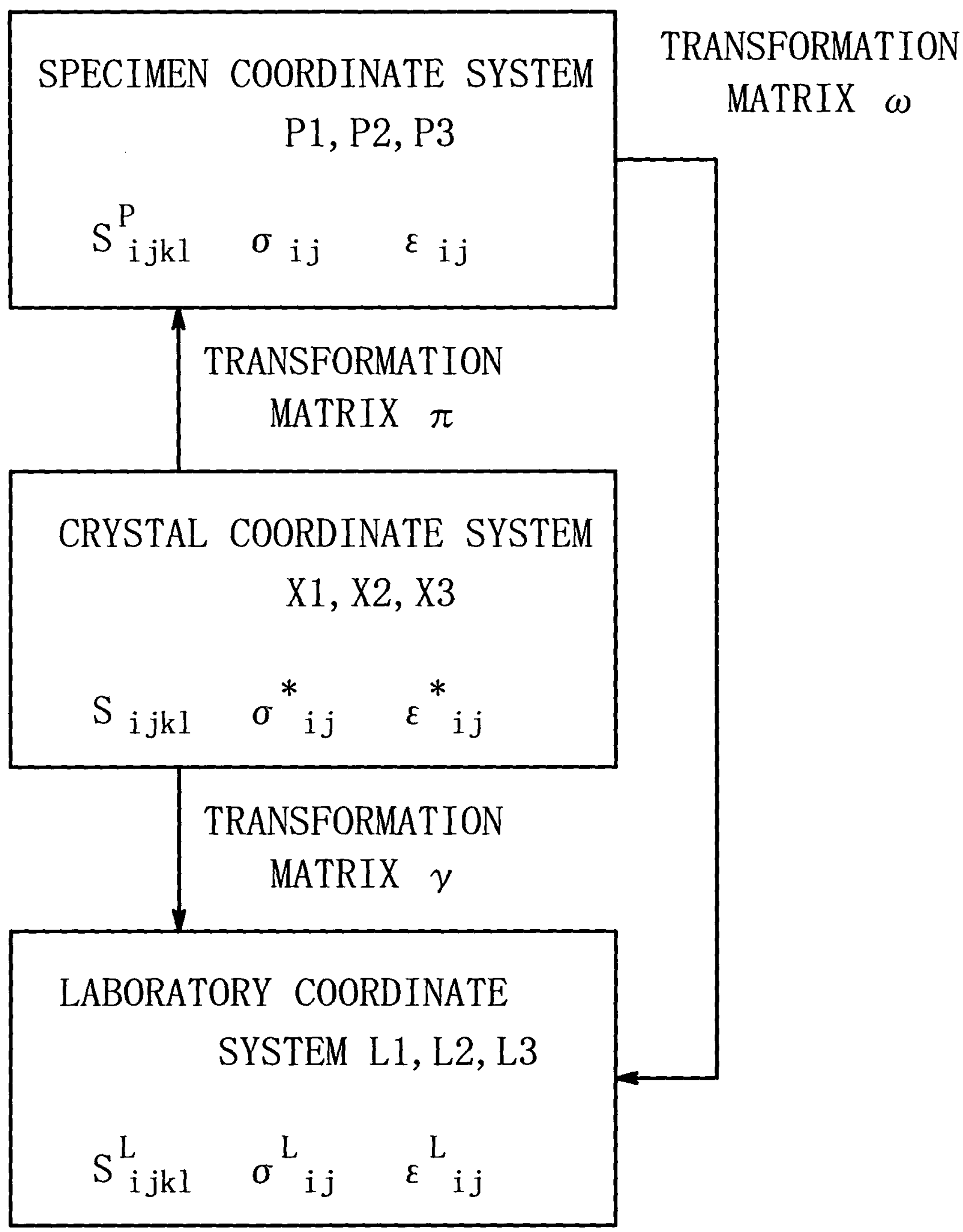

SPECIMEN COORDINATE SYSTEM
P1, P2, P3
S^{P}_{ijkl} σ_{ij} ε_{ij}
TRANSFORMATION MATRIX ω
TRANSFORMATION MATRIX π
CRYSTAL COORDINATE SYSTEM
X1, X2, X3
S_{ijkl} σ^{*}_{ij} ε^{*}_{ij}
TRANSFORMATION MATRIX γ
LABORATORY COORDINATE SYSTEM L1, L2, L3
S^{L}_{ijkl} σ^{L}_{ij} ε^{L}_{ij}

FIG. 5

	S	σ	ε
CRYSTAL COORDINATE SYSTEM	S_{ijkl}	σ^{*}_{ij}	ε^{*}_{ij}
SPECIMEN COORDINATE SYSTEM	S^{P}_{ijkl}	σ_{ij}	ε_{ij}
LABORATORY COORDINATE SYSTEM	S^{L}_{ijkl}	σ^{L}_{ij}	ε^{L}_{ij}

S: ELASTIC COMPLIANCE CONSTANT

σ : STRESS

ε : STRAIN

FIG. 6

ELASTIC COMPLIANCE CONSTANT IN TENSOR NOTATION

S_{ijkl} (i, j, k, l = 1, 2, 3)

RELATIONSHIP

6×6 MATIRIX IN MATRIX NOTATION

S_{pq} (p, q = 1, 2, 3, 4, 5, 6)

ij kl	11	22	33	23	32	13	31	12	21
p q	1	2	3	4	4	5	5	6	6

	p = 1, 2, 3	p = 4, 5, 6
q = 1, 2, 3	$S_{ijkl} = S_{pq}$	$S_{ijkl} = \frac{1}{2} S_{pq}$
q = 4, 5, 6	$S_{ijkl} = \frac{1}{2} S_{pq}$	$S_{ijkl} = \frac{1}{4} S_{pq}$

FIG. 7

$$\pi = R3(-\beta) \quad \cdots (5)$$

$$\omega = R2(-\psi)R3(-\phi) \quad \cdots (6)$$

$$\gamma = \omega\pi \quad \cdots (7)$$

$$R1(\delta) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\delta & -\sin\delta \\ 0 & \sin\delta & \cos\delta \end{pmatrix} \quad \cdots (8)$$

$$R2(\delta) = \begin{pmatrix} \cos\delta & 0 & \sin\delta \\ 0 & 1 & 0 \\ -\sin\delta & 0 & \cos\delta \end{pmatrix} \quad \cdots (9)$$

$$R3(\delta) = \begin{pmatrix} \cos\delta & -\sin\delta & 0 \\ \sin\delta & \cos\delta & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad \cdots (10)$$

$$\varepsilon^{L}_{33} = \gamma_{3i}\,\gamma_{3j}\,\varepsilon^{*}_{ij} \quad \cdots (11)$$

$$\varepsilon^{*}_{ij} = S_{ijkl}\,\sigma^{*}_{kl} \quad \cdots (12)$$

$$\sigma^{*}_{kl} = \pi_{pk}\,\pi_{ql}\,\sigma_{pq} \quad \cdots (13)$$

$$\varepsilon^{L}_{33} = \gamma_{3i}\,\gamma_{3j}\,S_{ijkl}\,\pi_{pk}\,\pi_{ql}\,\sigma_{pq} \quad \cdots (14)$$

FIG. 8

TETRAGONAL SYSTEM WITH LAUE SYMMETRY 4/mmm

$$S = \begin{bmatrix} S_{11} & S_{12} & S_{13} & 0 & 0 & 0 \\ S_{12} & S_{11} & S_{13} & 0 & 0 & 0 \\ S_{13} & S_{13} & S_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & S_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & S_{44} & 0 \\ 0 & 0 & 0 & 0 & 0 & S_{66} \end{bmatrix} \quad \cdots (15)$$

TETRAGONAL SYSTEM WITH LAUE SYMMETRY 4/m

$$S = \begin{bmatrix} S_{11} & S_{12} & S_{13} & 0 & 0 & S_{16} \\ S_{12} & S_{11} & S_{13} & 0 & 0 & -S_{16} \\ S_{13} & S_{13} & S_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & S_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & S_{44} & 0 \\ S_{16} & -S_{16} & 0 & 0 & 0 & S_{66} \end{bmatrix} \quad \cdots (16)$$

FIG. 9

$$\sigma_{11} = \sigma_{22} = \sigma \quad \cdots (17)$$

$$\sigma_{12} = \sigma_{13} = \sigma_{23} = \sigma_{33} = 0 \quad \cdots (18)$$

$$\varepsilon^{L}_{33} = (S_{11} + S_{12} - 2S_{13})\,\sigma \sin^{2}\psi + 2S_{13}\,\sigma \quad \cdots (19)$$

$$\sigma_{13} = \sigma_{23} = \sigma_{33} = 0 \quad \cdots (20)$$

FIG. 10

When $\phi = 0^\circ$

$$\begin{aligned}\varepsilon^{L}_{33}(0^\circ) = \frac{1}{8}\{&(6S_{11} + 2S_{12} - 8S_{13} + S_{66})\sigma_{11} + (2S_{11} + 6S_{12} \\ &- 8S_{13} - S_{66})\sigma_{22} + (2S_{11} - 2S_{12} - S_{66})(\sigma_{11} - \sigma_{22})\cos 4\beta \\ &- 2(S_{11} - 2S_{12} - S_{66})\sigma_{12}\sin 4\beta\}\sin^2\psi \\ &+ S_{13}(\sigma_{11} + \sigma_{22}) \qquad \cdots (21)\end{aligned}$$

When $\phi = 90^\circ$

$$\begin{aligned}\varepsilon^{L}_{33}(90^\circ) = \frac{1}{8}\{&(2S_{11} + 6S_{12} - 8S_{13} - S_{66})\sigma_{11} + (6S_{11} + 2S_{12} \\ &- 8S_{13} + S_{66})\sigma_{22} - (2S_{11} - 2S_{12} - S_{66})(\sigma_{11} - \sigma_{22})\cos 4\beta \\ &+ 2(S_{11} - 2S_{12} - S_{66})\sigma_{12}\sin 4\beta\}\sin^2\psi \\ &+ S_{13}(\sigma_{11} + \sigma_{22}) \qquad \cdots (22)\end{aligned}$$

FIG. 11

When $\phi = 45^\circ$

$$\varepsilon^{L}_{33}(45^\circ) = S_{13}(\sigma_{11}+\sigma_{22}) + \frac{1}{8}\{4(S_{11}+S_{12}-2S_{13})$$

$$(\sigma_{11}+\sigma_{22}) + 2(2S_{11}-2S_{12}+S_{66})\sigma_{12}\cos 4\beta$$

$$+ 2(S_{11}-2S_{12}+S_{66})(\sigma_{11}-\sigma_{22})\sin 4\beta\}\sin^2\psi \qquad \cdots(23)$$

FIG. 12

When $\phi = 0°$

$$\overline{\varepsilon^{L}_{33}(0°)} = \frac{1}{8}\{(6S_{11} + 2S_{12} - 8S_{13} + S_{66})\sigma_{11} + (2S_{11} + 6S_{12} - 8S_{13} - S_{66})\sigma_{22} + (2S_{11} - 2S_{12} - S_{66})(\sigma_{11} - \sigma_{22})\cos 4\beta\} \sin^{2}\psi + S_{13}(\sigma_{11} + \sigma_{22}) \quad \cdots(24)$$

When $\phi = 90°$

$$\overline{\varepsilon^{L}_{33}(90°)} = \frac{1}{8}\{(2S_{11} + 6S_{12} - 8S_{13} - S_{66})\sigma_{11} + (6S_{11} + 2S_{12} - 8S_{13} + S_{66})\sigma_{22} - (2S_{11} - 2S_{12} - S_{66})(\sigma_{11} - \sigma_{22})\cos 4\beta\} \sin^{2}\psi + S_{13}(\sigma_{11} + \sigma_{22}) \quad \cdots(25)$$

FIG. 13

When $\phi = 45^\circ$

$$\overline{\varepsilon^{L}_{33}(45^\circ)} = S_{13}(\sigma_{11}+\sigma_{22}) + \frac{1}{8}\{4(S_{11}+S_{12}-2S_{13})$$

$$(\sigma_{11}+\sigma_{22}) + 2(2S_{11}-2S_{12}+S_{66})\sigma_{12}$$

$$+2(2S_{11}-2S_{12}-S_{66})\sigma_{12}\cos 4\beta\}\sin^2\psi \quad \cdots(26)$$

FIG. 14

$$F1 = \left(\overline{\varepsilon^{L}_{33}(0^\circ)} + \overline{\varepsilon^{L}_{33}(90^\circ)} \right)/2$$

$$= \frac{1}{2}(S_{11} + S_{12} - 2S_{13})(\sigma_{11} + \sigma_{22})\sin^2\psi + S_{13}(\sigma_{11} + \sigma_{22}) \quad \cdots(27)$$

$$F2 = \left(\overline{\varepsilon^{L}_{33}(0^\circ)} - \overline{\varepsilon^{L}_{33}(90^\circ)} \right)/2$$

$$= (\sigma_{11} - \sigma_{22})V \quad \cdots(28)$$

$$F3 = \overline{\varepsilon^{L}_{33}(45^\circ)} - F1$$

$$= 2\sigma_{12}V \quad \cdots(29)$$

$$V = \frac{1}{8}\{2S_{11} - 2S_{12} + S_{66} + (2S_{11} - 2S_{12} - S_{66})\cos 4\beta\}\sin^2\psi \quad \cdots(30)$$

FIG. 15

LAUE SYMMETRY 4/mmm

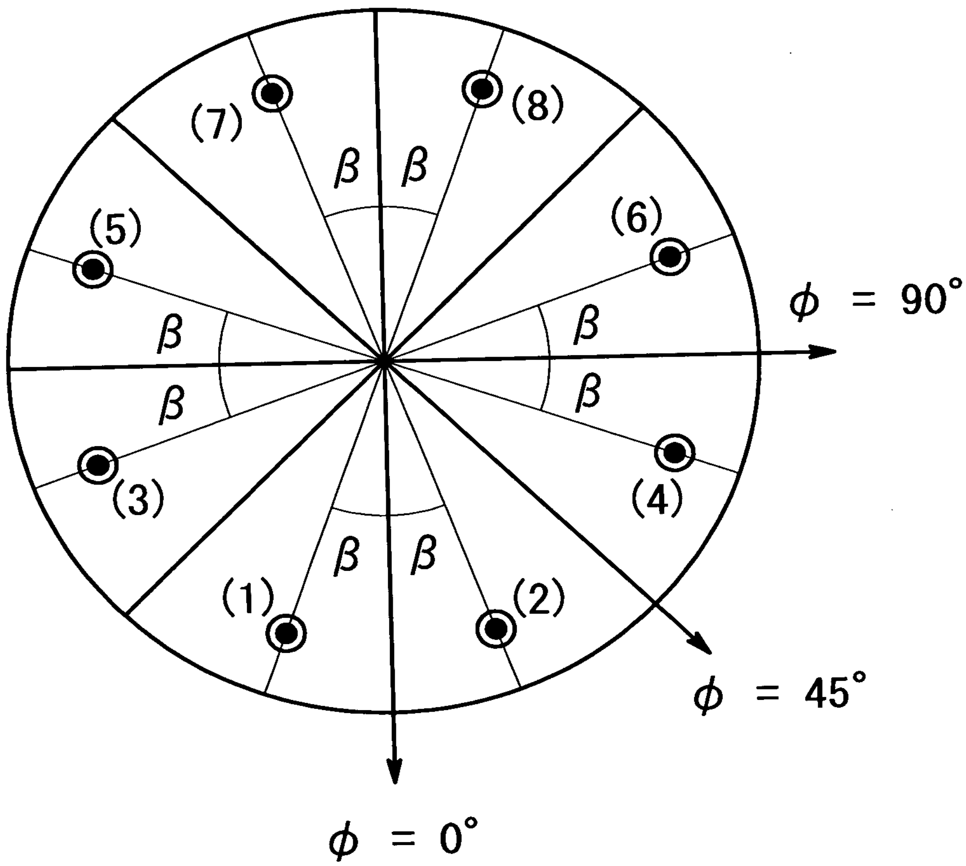


FIG. 16

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\phi=0°$	β	$-\beta$	$-\beta+\frac{\pi}{2}$	$\beta-\frac{\pi}{2}$	$\beta+\frac{\pi}{2}$	$-\beta-\frac{\pi}{2}$	$-\beta+\pi$	$\beta-\pi$
$\phi=45°$	$\beta-\frac{\pi}{4}$	$-\beta-\frac{\pi}{4}$	$-\beta+\frac{\pi}{4}$	$\beta-\frac{3\pi}{4}$	$\beta+\frac{\pi}{4}$	$-\beta-\frac{3\pi}{4}$	$-\beta+\frac{3\pi}{4}$	$\beta-\frac{5\pi}{4}$
$\phi=90°$	$\beta-\frac{\pi}{2}$	$-\beta-\frac{\pi}{2}$	$-\beta$	$\beta-\pi$	β	$-\beta-\pi$	$-\beta+\frac{\pi}{2}$	$\beta-\frac{3\pi}{2}$

FIG. 17

hkl	ψ (°)	β (°)	d_0(nm)	θ_0 (°)
002	0. 00	0. 00	0. 2078	21. 76
011	46. 81	0. 00	0. 2845	15. 71
112	36. 98	45. 00	0. 1668	27. 50
022	46. 81	0. 00	0. 1422	32. 79
211	67. 22	26. 57	0. 5151	28. 60
111	56. 42	45. 00	0. 2299	19. 58
013	19. 55	0. 00	0. 1305	36. 16
222	56. 42	45. 00	0. 1149	42. 08
301	72. 62	0. 00	0. 1241	38. 36

FIG. 18